A REVIEW OF THE PACIFIC ISLANDS SUBGENUS *NOTODACUS* PERKINS OF *BACTROCERA* MACQUART (DIPTERA: TEPHRITIDAE: DACINAE)

D.L. HANCOCK[1] and R.A.I. DREW[2]

[1]*8/3 McPherson Close, Edge Hill, Cairns, Qld 4870*

[2]*International Centre for the Management of Pest Fruit Flies, Griffith University, Qld 4111*

Abstract

The *Bactrocera* Macquart subgenus *Notodacus* Perkins is reviewed and four species recognised, including one undescribed. Based on both morphological and molecular evidence, the subgenus is transferred from the *Bactrocera* group of subgenera to the *Melanodacus* group of subgenera. A key to species is included.

Introduction

Subgenus *Notodacus* Perkins contains a small group of Pacific Island species, one of economic importance, that belong in the widespread genus *Bactrocera* Macquart. Traditionally included in the *Bactrocera* group of subgenera, based on morphology of the male terminalia in its type species *B. xanthodes* (Broun) (*e.g.* Drew 1972, 1989), subsequent information from later described species, together with molecular evidence, indicate an actual placement in the *Melanodacus* group of subgenera.

Genus *Bactrocera* Macquart

Subgenus *Notodacus* Perkins

Notodacus Perkins, 1937: 56. Type species *Dacus xanthodes* Broun, 1905 [= *Tephrites (Dacus) xanthodes* Broun, 1904], by original designation.

Definition. Abdominal sternite V of male broad with a shallow to deep posterior emargination (Figs 1-2); posterior lobe of male surstylus short; pecten of cilia present on abdominal tergite III of male; postpronotal setae present, placed posterolaterally; supra-alar and prescutellar acrostichal setae present; one pair of scutellar setae; scutum with a long and narrow medial postsutural yellow vitta and lateral presutural and postsutural yellow vittae; scutellum large and bilobed; pair of large [non-shiny] spots (ceromata) on abdominal tergite V present; head, thorax and abdomen fulvous to red-brown and with a glossy, transparent appearance; aculeus apically acute.

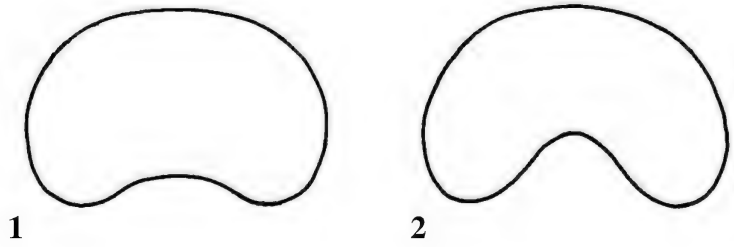
Response to male lures. Methyl eugenol (2 spp) or none known (2 spp).

Included species. *Bactrocera* (*N.*) *neoxanthodes* Drew & Romig, *B.* (*N.*) *paraxanthodes* Drew & Hancock, *B.* (*N.*) *xanthodes* (Broun), plus an undescribed sp. (Drew *et al*. 1997).

Host plants. Recorded from various families, with one species polyphagous.

Comments. The posterolateral postpronotal seta, glossy, transparent appearance and large, bilobed scutellum appear to be synapomorphies for this subgenus. Other defining characters are largely plesiomorphic. The

placement of the postpronotal seta suggests it is not homologous with the centrally placed seta seen in *B.* (*Heminotodacus*) *dissidens* Drew, or with the small, posterocentrally placed seta seen in *B.* (*Zeugodacus*) *hatyaiensis* Drew & Romig, with the seta evidently derived independently in each of these three cases.



Figs 1-2. *Bactrocera* (*Notodacus*) spp, male sternite V: (1) *B.* (*N.*) *neoxanthodes*; (2) *B.* (*N.*) *xanthodes*.

B. (*Notodacus*) *neoxanthodes* Drew & Romig (Fig. 3)

Bactrocera (*Notodacus*) sp. n. No. 2: Drew *et al*. 1997: 132.

Bactrocera (*Notodacus*) *neoxanthodes* Drew & Romig, 2001: 142. Type locality Kwero, Loh I., Vanuatu.

Fig. 3. *Bactrocera* (*Notodacus*) *neoxanthodes* female from Vanuatu. Photo by Steve K. Wilson © Pacific Community 2017.

Distribution. Vanuatu (Loh, Santo and Efaté islands).

Male lure. None known.

Host plants. Barringtonia edulis (Lecythidaceae) and *Passiflora suberosa* (Passifloraceae) (Drew and Romig 2001).

Comments. Male sternite V (Fig. 1) broad and weakly emarginate posteriorly. Adult illustrated in Fig. 3 and by Drew and Romig (2001) and Leblanc *et al.* (2012).

B. (*Notodacus*) *paraxanthodes* Drew & Hancock

Bactrocera (*Notodacus*) *paraxanthodes* Drew & Hancock, 1995: 10. Type locality Maré, New Caledonia [the handwritten locality 'Maré' was interpreted as 'Mavé' in the original description].

Distribution. New Caledonia: main island and Maré Island (Loyalty Islands). Records from Vanuatu and Samoa belong elsewhere (Drew *et al.* 1997).

Male lure. A possible weak attraction to methyl eugenol (Amice and Sales 1997, Drew *et al.* 1997).

Host plants. Schefflera gabriellae and *Meryta* sp. (Araliaceae) (Leblanc *et al.* 2012); a record from *Tylophora biglandulosa* (Apocynaceae) is doubtful, this being an asclepiad and host of *Dacus* (*Neodacus*) *aneuvittatus* Drew.

Comments. Shape of male sternite V not discernible on available specimens due to curvature of the lateral abdominal margins. This species was illustrated by Drew and Hancock (1995).

B. (*Notodacus*) *xanthodes* (Broun) (Figs 4-5)

Tephrites (*Dacus*) *xanthodes* Broun, 1904: 306. Type localities Rarotonga, Cook Is; Suva, Fiji; and Tonga [ex fruit imported into New Zealand].

Tephrites xanthodes Broun, 1905a [February]: 3. Type localities Rarotonga, Cook Is; Suva, Fiji; and Tonga [ex fruit imported into New Zealand]. Preoccupied: Broun 1904.

Dacus xanthodes Broun, 1905b [June]: 327. Type localities Rarotonga, Cook Is; Suva, Fiji; and Tonga [ex fruit imported into New Zealand]. Preoccupied: Broun 1904.

Chaetodacus xanthodes (Broun): Bezzi 1928: 105.

Dacus xanthodes (Broun): Malloch 1931: 260.

Notodacus xanthodes (Broun): Perkins 1937: 57.

Dacus (*Notodacus*) *xanthodes* (Broun): Hardy 1955: 434.

Bactrocera (*Notodacus*) *xanthodes* (Broun): Drew 1989: 170.

Distribution. American Samoa, Cook Islands (southern group), Fiji, French Polynesia (Austral group), Niue, Rotuma, Samoa, Tonga, Wallis and Futuna; eradicated from Nauru in 1999 (Leblanc *et al.* 2012). Records from Vanuatu are of *B. neoxanthodes* Drew & Romig (see above).

Male lure. Methyl eugenol.

Host plants. This species is highly polyphagous, being recorded from fruit of 34 plant species in 20 families, including many of economic importance (Leblanc *et al*. 2012). Breadfruit (*Artocarpus altilis*: Moraceae) is an important host on many islands (Tora Vueti *et al*. 1997). Records from Cucurbitaceae (*Citrullus lanatus*: watermelon) appear to refer only to damaged fruit (Leblanc *et al*. 2012).

Figs 4-5. *Bactrocera* (*Notodacus*) *xanthodes* from Samoa: (4) male; (5) female. Photos by Steve K. Wilson © Pacific Community 2017.

Comments. This species was described three times from the same type series bred from larvae found in fruit imported into New Zealand from Rarotonga, Suva and Tonga (Broun 1904, 1905a, 1905b), with their chronological sequence established by Norrbom *et al.* (1999). However, no types were designated and no specimens attributable to the original series are known to exist (Drew 1989). Male sternite V (Fig. 2) broad and relatively deeply emarginate posteriorly. Adult illustrated in Figs 4-5 and by Drew (1974, 1989). For a full description see Drew (1974).

B. (*Notodacus*) undescribed species 1

Bactrocera (*Notodacus*) *paraxanthodes* Drew & Hancock, 1995: 10. *Partim*: Western Samoa records only; misidentification.

Bactrocera (*Notodacus*) sp. n. No. 1: Drew *et al.* 1997: 132; Leblanc *et al.* 2012: 35.

Distribution. Samoa.

Male lure. None known.

Host plants. Ficus sp. (Moraceae) (Drew and Hancock 1995), plus *Meryta* sp. (Araliaceae) and *Mammea glauca* (Calophyllaceae) (Leblanc *et al.* 2012).

Comments. Examined specimens are teneral with curled abdomens, the shape of male sternite V thus not discernible. This species has not been illustrated but distinguishing characters were noted by Drew *et al.* (1997).

Key to species of subgenus *Notodacus*

* = presumed apomorphic characters.

1 Wing with costal band narrow and uniformly fuscous from end of vein R_{2+3} to apex; scutum red-brown, contrasting with fulvous abdomen and with a narrow whitish to pale yellow medial vitta extending as a fulvous area to hind margin and fulvous anterior to suture; scutellum red-brown laterally, fulvous medially and with distinct whitish or yellow lateral margins over at least basal half*; male sternite V deeply emarginate posteriorly*; female oviscape extensively black posteriorly* [numerous South Pacific islands; Figs 4-5] ..... *B.* (*N.*) *xanthodes* (Broun, 1904)

– Wing with costal band either broad and uniformly pale or narrow and pale except fuscous at apex; scutum orange-brown with the yellow medial vitta continuing anterior to suture; scutellum without distinct yellow margins but an indistinct yellow area sometimes present; male sternite V either not described or with a shallow emargination posteriorly; female oviscape entirely or almost entirely fulvous 2

2 Wing with costal band narrow and confluent with vein R_{2+3}, dark fuscous at apex of cell r_{4+5} but paler elsewhere*; scutellum fulvous centrally and broadly dark fulvous to pale fuscous laterally, sometimes with a small yellow basolateral area [Vanuatu; Fig. 3] .... *B.* (*N.*) *neoxanthodes* Drew & Romig, 2001

– Wing with costal band broad and confluent with vein R_{4+5}, entirely pale, not dark fuscous apically; scutellum not as above 3

3 Wing without a pale, transverse infuscation enclosing crossveins; scutellum fulvous with black lateral vittae reaching apical setae posteriorly but ending narrowly before base anteriorly* [New Caledonia] ..... *B.* (*N.*) *paraxanthodes* Drew & Hancock, 1995

– Wing with a narrow, pale transverse infuscation enclosing both crossveins R-M and DM-Cu*; scutellum fulvous without black lateral vittae [Samoa] ..... *B.* (*N.*) undescribed sp. (No. 1 of Drew *et al.* 1997)

Discussion

Subgenus *Notodacus* species are known only from islands of the South Pacific (Zone F of Hancock and Drew 2015). They have individual apomorphies (see Key) and do not appear to form related pairs or triplets. Rather, they appear to represent vicariant species derived from a single ancestral entity, with the most polyphagous species, *B. xanthodes*, subsequently dispersing (most likely by human introduction) throughout much of the South Pacific. The remaining three species appear to be endemic (and restricted) to single island groups (New Caledonia, Vanuatu and Samoa respectively), suggesting that *B. xanthodes* originated in Fiji.

The male sternite V (Figs 1-2) is broader than in the *Bactrocera* group of subgenera, resembling more that of the *Zeugodacus* and *Melanodacus* groups (*cf.* Drew 1972, figs 1-2); hence, despite the relatively deep emargination in the type species, *Notodacus* is referred here to the *Melanodacus* group of subgenera. This is supported by molecular studies (Krosch *et al.* 2012, Virgilio *et al.* 2015), which both placed *B.* (*Notodacus*) *xanthodes* in a clade with other *Melanodacus* group subgenera such as *Daculus* Speiser, *Gymnodacus* Munro and (Krosch *et al.* 2012) *Paratridacus* Shiraki. Leblanc *et al.* (2015) placed *B.* (*N.*) *xanthodes* as basal to both *Daculus* and the *Bactrocera* group.

Jiang *et al.* (2016) also showed that the *Bactrocera* and *Melanodacus* groups of subgenera formed separate monophyletic clades and followed Krosch *et al.* (2012) in placing *Tetradacus* Miyake as a separate lineage basal to both groups, all separated from the *Zeugodacus* group of subgenera (and other examined genera of Dacinae and Tephritinae) in possessing a TA (apomorphy) instead of TAA stop codon (plesiomorphy) for the COI gene.

The presence of presutural and postsutural lateral yellow vittae and a medial yellow vitta on the scutum, plus a single pair of scutellar setae, suggest a relationship with subgenus *Tetradacus* (*sensu* Hancock and Drew 2015), which has similarly short posterior surstylus lobes and a shallow emargination to sternite V in males. *Tetradacus*, however, differs in having a normally shaped scutellum and in lacking postpronotal, prescutellar acrostichal and, usually, supra-alar setae.

Notodacus also resembles the *B.* (*H.*) *aglaiae* (Hardy) group of subgenus *Hemizeugodacus* Hardy (*sensu* Hancock and Drew 2015) in possessing a medial yellow vitta on the scutum and retaining both supra-alar and prescutellar acrostichal setae, but the latter has two pairs of scutellar setae. *Hemizeugodacus,* however, is likely to be the most closely related subgenus, the lack of basal scutellar setae in *Notodacus* being possibly a consequence of its distinctly modified scutellum.

Acknowledgements

We thank Susan Wright (Queensland Museum, Brisbane) for images of the handwritten type labels of *B. paraxanthodes* and access to specimens. We also thank Steve Wilson (Queensland Museum, Brisbane) and the Secretariat of the Pacific Community, Nouméa (per Stuart Roberts) for provision of Figs 3-5 and permission to use them.

References

AMICE, R. and SALES, F. 1997. Fruit fly fauna in New Caledonia. Pp 68-76, in: Allwood, A.J. and Drew, R.A.I. (eds), *Management of fruit flies in the Pacific. ACIAR Proceedings* **76**: 1-267.

BEZZI, M. 1928. *Diptera Brachycera and Athericica of the Fiji Islands*. British Museum (Natural History), London; viii + 220 pp.

BROUN, T. 1904. Description of *Tephrites (Dacus) xanthodes* – new species. *Annual Report of the New Zealand Department of Agriculture* **12**: 306-307.

BROUN, T. 1905a. Description of three species of fruit flies. *Bulletin of the New Zealand Department of Agriculture Division of Biology and Horticulture* **4**: 3-6.

BROUN, T. 1905b. Notes on fruit flies, with a description of a new species (*Dacus xanthodes*). *Transactions and Proceedings of the New Zealand Institute* (Wellington) (1904) **37**: 323-328.

DREW, R.A.I. 1972. The generic and subgeneric classification of Dacini (Diptera: Tephritidae) from the South Pacific area. *Journal of the Australian Entomological Society* **11**: 1-22.

DREW, R.A.I. 1974. Revised descriptions of species of Dacini (Diptera: Tephritidae) from the South Pacific area. II. The *Strumeta* group of subgenera of genus *Dacus*. *Queensland Department of Primary Industries Division of Plant Industry Bulletin* **653**: 1-101.

DREW, R.A.I. 1989. The tropical fruit flies (Diptera: Tephritidae: Dacinae) of the Australasian and Oceanian Regions. *Memoirs of the Queensland Museum* **26**: 1-521.

DREW, R.A.I. and HANCOCK, D.L. 1995. New species, subgenus and records of *Bactrocera* Macquart from the South Pacific (Diptera: Tephritidae: Dacinae). *Journal of the Australian Entomological Society* **34**: 7-11.

DREW, R.A.I. and ROMIG, M.C. 2001. The fruit fly fauna (Diptera: Tephritidae: Dacinae) of Bougainville, the Solomon Islands and Vanuatu. *Australian Journal of Entomology* **40**: 113-150.

DREW, R.A.I., ALLWOOD, A.J. and TAU, D. 1997. *Bactrocera paraxanthodes* Drew and Hancock – an example of how host records and attractant responses contribute to taxonomic research. Pp 131-133, in: Allwood, A.J. and Drew, R.A.I. (eds), *Management of fruit flies in the Pacific. ACIAR Proceedings* **76**: 1-267.

HANCOCK, D.L. and DREW, R.A.I. 2015. A review of the Indo-Australian subgenus *Parazeugodacus* Shiraki of *Bactrocera* Macquart (Diptera: Tephritidae: Dacinae). *Australian Entomologist* **42**(2): 91-104.

HARDY, D.E. 1955. A reclassification of the Dacini (Tephritidae–Diptera). *Annals of the Entomological Society of America* **48**: 425-437.

JIANG, F., PAN, X., LI, X., YU, Y., ZHANG, J., JIANG, H., DOU, L. and ZHU, S. 2016. The first complete mitochondrial genome of *Dacus longicornis* (Diptera: Tephritidae) using next-generation sequencing and mitochondrial genome phylogeny of Dacini tribe. *Scientific Reports* **6**: 36426; doi: 10.1038/srep36426. 22 pp.

KROSCH, M.N., SCHUTZE, M.K., ARMSTRONG, K.F., GRAHAM, G.C., YEATES, D.K. and CLARKE, A.C. 2012. A molecular phylogeny for the tribe Dacini (Diptera: Tephritidae): systematic and biogeographical implications. *Molecular Phylogeny and Evolution* **64**: 513-523.

LEBLANC, L., SAN HOSE, M., BARR, N. and RUBINOFF, D. 2015. A phylogenetic assessement of the polyphyletic nature and intraspecific color variation in the *Bactrocera dorsalis* complex (Diptera, Tephritidae). *Zookeys* **540**: 339-367.

LEBLANC, L., TORA VUETI, E., DREW, R.A.I. and ALLWOOD, A.J. 2012. Host plant records for fruit flies (Diptera: Tephritidae: Dacini) in the Pacific Islands. *Proceedings of the Hawaiian Entomological Society* **44**: 11-53.

MALLOCH, J.R. 1931. Diptera, Trypetidae. *Insects of Samoa and other terrestrial Samoan Arthropoda* **6**(7): 253-266. British Museum (Natural History), London.

NORRBOM, A.L., CARROLL, L.E., THOMPSON, F.C., WHITE, I.M. and FREIDBERG, A. 1999. Systematic database of names. Pp 65-251, in: Thompson, F.C. (ed.), Fruit fly expert identification system and systematic information database. *Myia* **9**: ix + 524 pp.

PERKINS, F.A. 1937. Studies in Australian and Oriental Trypaneidae. Part I. New genera of Dacinae. *Proceedings of the Royal Society of Queensland* **48**: 51-60.

TORA VUETI, E., ALLWOOD, A.J., LEWENIQILA, L., RALULU, L., BALAWAKULA, A., MALAU, A., SALES, F. and PELETI, K. 1997. Fruit fly fauna in Fiji, Tuvalu, Wallis and Futuna, Tokelau and Nauru. Pp 60-63, in: Allwood, A.J. and Drew, R.A.I. (eds), *Management of fruit flies in the Pacific. ACIAR Proceedings* **76**: 1-267.

VIRGILIO, M., JORDAENS, K., VERWIMP, C., WHITE, I.M. and DE MEYER, M. 2015. Higher phylogeny of frugivorous flies (Diptera: Tephritidae: Dacini): localised partition conflicts and a novel generic classification. *Molecular Phylogenetics and Evolution* **85**: 171-179.